Screening Women for Gonorrhea: Demographic Screening Criteria for General Clinical Use

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ABSTRACT

Objectives. The purpose of this analysis was to derive potential gonorrhea screening criteria for women.

Methods. Data corresponding to 44 366 gonorrhea cultures from women 15 through 44 years of age in Columbus, Ohio, were analyzed.

Results. Characteristics that were associated with gonococcal infection and were suitable for screening decisions included patient's age and marital status and previous prevalence of gonorrhea at provider site. Probabilities of infection ranged from .001 for married women 25 through 44 years of age at low-prevalence provider sites to .078 for unmarried women 15 through 19 years of age at high-prevalence sites.

Conclusions. Patient's age and marital status and prevalence of gonorrhea at provider site can be used as indicators to ensure testing of high-prevalence groups. (*Am J Public Health.* 1997;87:1535–1538)

Introduction

Although routine screening of women for gonorrhea to detect asymptomatic infections and prevent both transmission and long-term sequelae has been a major component of gonorrhea control programs, there are no comprehensive screening guidelines. The Centers for Disease Control and Prevention recommends screening all pregnant women and all women presenting to sexually transmitted disease clinics.[1,2] The Preventive Services Task Force recommends screening "persons at high risk," including women who have multiple sex partners, a partner with multiple partners, a partner with gonorrhea, or a history of repeated infections.[3] Determining which women are at risk, however, may be difficult without simpler, more specific guidelines.

The gonorrhea screening program in Columbus, Ohio, has supported testing for more than 50 000 women per year at a variety of participating sites. Data from this screening program were analyzed to derive potential screening criteria for gonorrhea for use outside sexually transmitted disease clinics and prenatal care settings.

Methods

From 1972 to 1993, the Columbus Health Department supported gonorrhea testing and collected information on all women receiving pelvic examinations at more than 60 participating provider sites, including family planning clinics, private physicians' offices, obstetrics and gynecology clinics, emergency rooms, neighborhood health centers, hospital outpatient clinics, correctional institutions, and student health centers. Our analysis was restricted to women 15 through 44 years of age tested for gonorrhea in 1991. Women who were pregnant, had pelvic inflammatory disease, or had known exposure to a sexually transmitted disease were excluded because screening recommendations for these groups had already been established.[1,2] Women undergoing a test of cure also were excluded from the analysis. Women tested by providers submitting fewer than 100 tests in 1990 or 1991 (2% of the total tests) were excluded as well because of imprecise estimates of gonorrhea prevalence at these provider sites.

Specimens from the endocervix were inoculated onto Martin–Lewis media; these media were placed in a carbon dioxide–enriched environment, transported via courier to the Columbus Health Department Laboratory, and incubated at 34° to 36°C for 48 hours. Presumptive identification was based on Gram-stained appearance, colony morphology, and positive oxidase test results.

A standardized reporting form completed by providers at the time of examination included information on the patient's sex, age, race, marital status, zip code of residence, the reason for the examination, and the provider site. Culture results were added at the health department. An additional variable was provider site prevalence, calculated with gonococcal test data from 1990 (the year before the study period). Provider site prevalences were defined as high if they were greater than 3%, medium if they were 1% to 3%, and low if they were less than 1%. The center city area was defined as four zip codes surrounding the health department building in downtown Columbus.

We used the chi-squared statistic to determine the significance of the univariate association between each demographic variable and gonorrhea culture results. Multivariate logistic regression

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TABLE 1—Number of Women 15 through 44 Years Tested for Gonorrhea and Prevalence of Gonorrhea, by Selected Characteristics: Columbus, Ohio, 1991

	No. Tested	Positive No. (%)
Age, y		
15–19	9 596	289 (3.0)
20–24	14 807	278 (1.9)
25–44	19 963	216 (1.1)
Marital status[a]		
Unmarried	32 351	637 (2.0)
Married	7 760	29 (0.4)
Race[b]		
White	24 741	112 (0.5)
Black	16 864	604 (3.6)
Other	893	10 (1.1)
Zip code of residence[c]		
Center city	5 484	200 (3.6)
Other	34 697	512 (1.5)
Provider type		
Family planning	17 529	107 (0.6)
Private physician	14 949	342 (2.3)
Obstetrics/gynecology clinic	5 032	58 (1.2)
Emergency room	4 062	203 (5.0)
Other	2 794	73 (2.6)
Prevalence at provider site (1990), %		
>3	9 942	474 (4.8)
1–3	9 811	164 (1.7)
<1	24 613	145 (0.6)
Total	44 366	783 (1.8)

[a]Information was missing for 9.6% of tests.
[b]Information was missing for 4.2% of tests.
[c]Information was missing for 9.4% of tests.

TABLE 2—Adjusted Odds Ratios for Gonococcal Infection in Women 15 through 44 Years in Columbus, Ohio, 1991: Multiple Logistic Regression Analysis

	Adjusted Odds Ratio	95% Confidence Interval
Prevalence at provider site (1990) %		
>3	8.6	7.0, 10.5
1–3	3.3	2.6, 4.2
<1	1.0	. . .
Age group, y		
15–19	2.6	2.1, 3.2
20–24	1.8	1.5, 2.2
25–44	1.0	. . .
Marital status		
Unmarried	3.4	2.4, 5.0
Married	1.0	. . .

analyses included variables that were considered to be appropriate screening criteria and that were shown to be significant in univariate analyses; race, zip code of residence, and type of provider site were all excluded. The significance of interaction terms was determined by the "chunk" test.[4]

Using the logistic regression equation, we calculated each patient's predicted probability of gonococcal infection. We then used all possible predicted probabilities of infection as cut points. For each cutpoint, we grouped women according to whether their predicted probability of infection was greater than or less than the cutpoint. Assuming that only those with a predicted probability above the cutpoint were screened, we calculated the percentage of infections that would have been detected (sensitivity) and the percentage of uninfected women who would have been tested unnecessarily (1 − specificity). These values were plotted for each cutpoint to form a receiver operating characteristic (ROC) curve. ROC Analyzer software[5] was used in calculating the area under the curve. Two points at which the slope of the curve decreased substantially (indicating a decrease in infections detected per uninfected women tested) were selected as optimal cutpoints for screening.

Using $4.25 as the estimated cost of a gonorrhea culture in a public health setting (W.L. Whittington, Neisseria Reference Lab, University of Washington, July 1994), we calculated the cost per infection detected for women grouped by demographic profile.

The 1992 data for gonococcal testing among women 15 to 44 years of age were used as the validation data set, with the same exclusion criteria as for 1991 data. Prevalence at provider site during 1991 was determined and included in the data set. Using the logistic regression model developed with 1991 data and the 18 corresponding predicted probabilities of infection as cut points, we calculated the sensitivity and specificity of screening criteria corresponding to each cut point using 1992 data. We constructed the corresponding receiver operating characteristic curve and calculated its area.[5]

Results

In 1991, 44 366 gonorrhea cultures from women 15 to 44 years of age at 50 provider sites were included in the analysis. The majority of women tested were less than 25 years old (55%), White (58%), unmarried (81%), and living outside the center city area (86%) (Table 1). Almost three quarters of the women were seen at family planning clinics (40%) or by private physicians (34%), and more than half (55%) were tested at provider sites with a low prevalence (<1%) of gonorrhea during the previous year.

The overall prevalence of gonorrhea in the study population in 1991 was 1.8%. The prevalence was higher in adolescents, unmarried women, African-American women, those seen at emergency rooms and private physicians' offices, and those seen at high-prevalence provider sites (prevalences of greater than 3% during the previous year) (Table 1).

On the basis of the univariate analysis and their suitability as screening criteria, age group, marital status, and previous year's provider site prevalence were included in the logistic regression model. All three variables were significantly associated with gonococcal infection. Interaction terms did not contribute significantly to the model. Previous prevalence at provider site was the strongest predictor of disease, with an adjusted odds ratio of 8.6 for tests performed at high-prevalence sites (Table 2).

As determined by the logistic regression equation, predicted probabilities of infection ranged from .001 to .078 for 18 groups of women categorized according to age group, marital status, and prevalence at provider site (Table 3). Women with the highest predicted probability of infection were 15 to 19 years old, unmarried, and tested at high-prevalence provider sites. Those with the lowest predicted probability were 25 to 44 years old, married, and tested at low-prevalence provider sites.

The receiver [illegible]g characteristic curve (Figure 1), [illegible]h shows the trade-off between the percentage of infections detected and the percentage of uninfected women screened as the cut point varies, had an area of 0.78 (SE = 0.008). Points A and B (Figure 1) were chosen as two plausible optimal cut points. The slope of the curve to the right of point A was always less than 1.0; screening women in this range would increase the percentage of uninfected women tested more than the percentage of infections detected. The slope to the right of point B was always less than 0.25; screening women in this range would increase the percentage of uninfected women tested more than four times faster than the percentage of infections detected.

Point A corresponds to a predicted probability of infection of .0168. If only women with a predicted probability of .0168 or more had been screened in 1991, 73% of infections would have been detected, and 27% of the uninfected women would have been tested. This would have involved screening women at high-prevalence provider sites who were less than 25 years old or unmarried, screening women at medium-prevalence provider sites who were both less than 25 years old and unmarried, and not screening women at low-prevalence sites (profiles 1–7).

Point B corresponds to a predicted probability of infection of .0068. If only women with a predicted probability of .0068 or more had been screened in 1991, 96% of infections would have been detected, but 70% of uninfected women would have been screened unnecessarily. This would have involved screening all women at high-prevalence sites, those either less than 20 years old or unmarried at medium-prevalence sites, and those less than 25 years old and unmarried at low-prevalence sites (profiles 1–12).

The cost per case of gonococcal infection detected ranged from $57 for the group with the highest predicted probability of infection to $4929 for the group with the lowest predicted probability of infection (Table 3).

Applying the model parameters developed with 1991 data to the 1992 gonorrhea screening data produced a very similar receiver operating characteristic curve (area = 0.79, SE = 0.010), despite a drop in overall prevalence of gonorrhea from 1.8% in 1991 to 1.2% in 1992.

TABLE 3—Predicted and Observed Probability of Gonococcal Infection and Cost per Infection Detected, by Prevalence at Provider Site and Age and Marital Status of Patients: Columbus, Ohio, 1991

Profile	Provider Prevalence[a]	Age Group, y	Marital Status	Predicted Probability of Infection[b]	Observed Probability of Infection	Cost per Infection Detected, $
1	High	15–19	U	.078	.075	57
2	High	20–24	U	.056	.053	79
3	Medium	15–19	U	.032	.029	145
4	High	25–44	U	.032	.035	122
5	High	15–19	M	.024	.016	264
6	Medium	20–24	U	.022	.025	167
7	High	20–24	M	.017	.037	115
8	Medium	25–44	U	.013	.012	347
9	Low	15–19	U	.010	.012	349
10	Medium	15–19	M	.009	.000	. . .
11	High	25–44	M	.009	.006	699
12	Low	20–24	U	.007	.006	708
13	Medium	20–24	M	.007	.003	1675
14	Low	25–44	U	.004	.003	1508
15	Medium	25–44	M	.004	.004	1098
16	Low	15–19	M	.003	.000	. . .
17	Low	20–24	M	.002	.003	1612
18	Low	25–44	M	.001	.001	4929

Note. Patients were women aged 15 through 44 years. U = unmarried; M = married.
[a]High: >3%; medium: 1–3%; low: <1%.
[b]P (infection) = 1/[1 + exp [6.8044 − (2.1488 × high prevalence) − (1.1995 × medium prevalence) − (0.9521 × age 15 to 19) − (0.5899 × age 20 to 24) − (1.2381 × unmarried)]]. Predictor variables were coded as 1 if the characteristic was present and 0 otherwise.

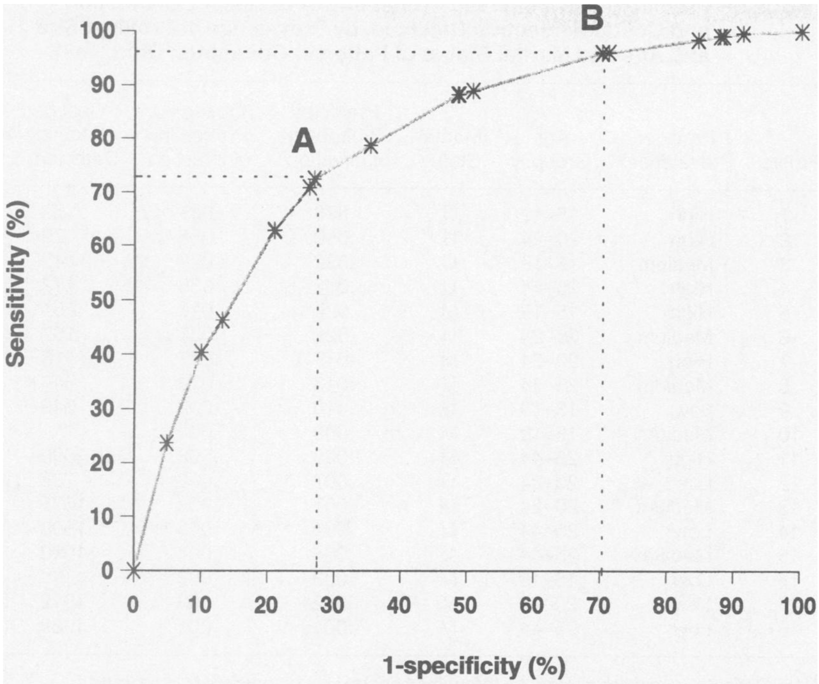
Discussion

Given a fixed gonorrhea screening budget, resources should be used to screen women with the highest predicted probability of gonococcal infection. Groups with lower predicted prevalences should be added as resources permit. In Columbus, one possibility is to screen women who are less than 25 years of age or women who are not married at high-prevalence sites and to test women who are less than 25 years of age and unmarried at medium-prevalence sites. An alternative would be to screen all women at high-prevalence sites, screen women who are less than 20 years of age or women who are not married at medium-prevalence sites, and screen women who are less than 25 years of age and unmarried at low-prevalence sites. The criteria are simple to use for providers who know the prevalence of gonorrhea among their female patient population.

The variables used to determine these proposed screening criteria were age, marital status, and previous prevalence at provider site. Race, zip code of residence, and provider type were also significantly associated with gonococcal infection among women in Columbus tested in 1991, but these variables were not included in the logistic regression model. Race is a risk marker for gonococcal infection, but we believe that it is inappropriate to use race as a screening criterion for a potentially stigmatizing disease that does not have a genetic basis. Zip code and provider type were not used because of the difficulty in translating possible screening criteria to other geographic areas.

The shape of a receiver operating characteristic curve is indicative of the performance of a model. A perfect model would identify all infected women but no uninfected women, and the receiver operating characteristic curve would be an upside-down L (area = 1.0). The closer the area under the curve to 1.0, the better the model. If women were tested randomly, regardless of risk of infection, the curve would be a diagonal line, and the area below the curve would be equal to 0.5. Our model performs considerably better than that (area = 0.78) and better than more complicated models developed for chlamydia.[6] The model performs consistently as well, as shown by the validation data set.

This study has several limitations. First, data on sexual behavior, which may be more strongly associated with disease than demographic factors, were not collected. For example, number of recent sex partners may be more predictive of infection than marital status. Second, the patterns of gonococcal infection among women in Columbus may not represent patterns in other communities. Cities that have a much higher or lower prevalence of gonorrhea should analyze their own data to determine the applicability of our proposed criteria. Third, we considered all



Note. Points A and B represent points to the right of which the slope of the curve decreases substantially; thus, the screening criteria corresponding to these points are proposed as efficient criteria.

FIGURE 1—Receiver operating characteristic curve showing the trade-off between sensitivity and specificity for different screening criteria among women 15 through 44 years of age in Columbus, Ohio, 1991.

gonococcal infections to be of equal importance, when in fact some women are much more likely to transmit infections than others, and some women are more likely to suffer from sequelae than others. In addition, using provider site prevalence as a screening criterion may have a practical limitation. It requires providers to maintain statistics on prevalence and periodically screen a representative sample of patients for gonorrhea in order to reassess overall prevalence.

In determining how best to allocate resources, it is reasonable to compare the cost per infection detected by screening with other control activities, such as partner notification. Our listing of cost per infection detected gives programs an approximate value for screening activities, but the cost per test in other areas may not be $4.25, depending on clinic setting, laboratory setting, and volume of testing. Determining the optimal allocation of resources for gonorrhea screening, however, requires more in-depth economic analyses. Phillips et al., in the 1980s, estimated that screening would reduce overall costs at a prevalence of 1.5%, assuming that the cost of a gonorrhea culture was $9.[7] This estimate, however, was based on the treatment practices and cost of sequelae in the 1980s and did not take into account the cost of transmission from untreated cases. More up-to-date and comprehensive cost analyses are needed. Until programs can determine the optimal amount of screening through economic analyses, we propose testing women at highest risk on the basis of prevalence of gonorrhea at the provider site and patient's age and marital status, as resources permit. □

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